PREPRODUCTION INITIATIVE—NELP
AIRCRAFT DEICING AND AQUEOUS FILM FORMING FOAM WASTEWATER TREATMENT SYSTEM
COST ANALYSIS

PROTOTYPE SITE: NAS Whidbey Island, WA

DESCRIPTION: The treatment system is based on anaerobic fluidized bed reactor technology. Contaminated wastewater is passed upward through a bed of granular activated carbon (GAC) that has been coated with microorganisms (biomass). The force of the incoming wastewater hydraulically fluidizes the GAC bed within the reactor. As the incoming wastewater mixes with the microorganisms, they break down the complex organic compounds in the waste and produce methane, carbon dioxide, water, and additional biomass. To aid in this digestion process, small amounts of nutrients and pH control chemicals are added to the incoming wastewater prior to its entry into the reactor vessel. This digestion process reduces the overall strength of the wastewater making it possible to discharge the resulting effluent to the local treatment works for final disposal.

DATA COLLECTION PERIOD: April 2000 – July 2000

COST SAVINGS: Treating and disposing of wastewaters containing high concentrations of organic materials and/or foaming surfactants is often problematic for Navy facilities. Periodic introduction of these wastes into existing conventional treatment systems frequently results in costly system upsets and shutdowns. Consequently, facilities that generate substantial amounts of deicing fluid and aqueous film forming foam (AFFF) wastewater are often subject to surcharges, fines, or in many cases, forced to have their wastes hauled offsite to an industrial wastewater treatment plant. All of these eventualities result in excess disposal costs.

By pretreating these wastes with a treatment system of the type tested here, their strength and/or foaming potential is reduced. This will allow the wastes to be discharged to the local treatment works and will eliminate or greatly reduce previously incurred surcharges. In addition, the tested system generates methane as a byproduct of the digestion process. If sufficient volumes of wastewater are treated, this methane could be captured and used to reduce facility space heating. Another alternative that might be feasible in the near future is the use of the generated methane to power a fuel cell and produce electricity.

Because the prototype test was performed using a pilot-scale reactor, two analyses are included herein:

- One analysis covers the implementation of the tested pilot-scale system. For this analysis, it was assumed that the majority of the wastewater being treated will be (as was the case in the prototype test) AFFF wastewater. It was also assumed that this wastewater will be generated and treated over the course of 270 days. Finally, NASWI (the test site for this PPEP project) was selected as the location for the analysis because of the availability of treatment system cost and operational data.
- The second analysis is for a full-scale treatment system capable of treating 100,000 gallons of deicing wastewater per year. For this analysis, it was assumed that wastewater will be generated primarily during the three month winter season and treated over the course of 300 days (including the winter season). NAS Brunswick was used as the location for this analysis because of the level of glycol deicing operations at the site and the availability of glycol usage data for the site. In addition, because of the ongoing phaseout of AFFF and the foaming problems experienced at higher AFFF

influent flow rates during the prototype test, the impact of treating this waste was not considered in the cost analysis for the full-scale system.

PILOT-SCALE ANALYSIS ***(takes into account costs of both deicing and AFFF wastes)***

PREVIOUS METHOD: Offsite Disposal

Consumables **— N/A**

Labor **— N/A**

Outside Laboratory Costs **– N/A (see note 5)**

Waste Disposal

Volume of AFFF Wastewater disposed of per year	11,759 gallons	(see note 6)
Cost for disposal per gallon	$3.00	
Volume of Deicing Fluid Wastewater disposed of per year	361 gallons	(see note 6)
Cost for disposal per gallon	$1.83	
Total cost per year	$35,937.63	

NELP METHOD: AFBR Pretreatment with Subsequent Discharge to NOTW (see note 7)

Consumables **– Treatment System Chemicals (see note 8)**

Cost per 55 gallon barrel of caustic	$181.00
Number of barrels used per year	3
Total cost of caustic per year	$543.00
Cost of nutrients per gallon of wastewater treated	$.004785
Number of gallon of wastewater treated per year	12,120
Total cost of nutrients per year	$58.00
Total Annual Cost of Treatment System Chemicals	$601.00

Labor (based on 270 consecutive operating days per year with weekly checks during non-operational period and using an available technician on a part-time basis)

Average hourly pay rate of Wastewater Plant Technician	$18.14	
Average man-hours per year to operate and maintain AFBR system	565	(see note 9)
Total Labor Cost Per Year	$10,249.10	

Electricity (see note 10)

NASWI electricity rate per kilowatt-hour (kWh)	$0.0459
Average power draw for system during test (kW)	3.14
Annual hours of system operation (270 days @ 24hrs/day)	6,480
Projected kWh required to operate AFBR system for one year	20,347
Total Electricity Cost Per Year	$933.94

Outside Laboratory Costs (see note 11)

Weekly analysis cost	$135.00
Weeks of operation/discharge	39
Total annual analysis cost	$5,265.00

Total Annual Operating Costs

Item	**Cost**
Consumables	$601.00
Labor	$10,249.10
Electricity	$933.94
Outside laboratory costs	$5,265.00
Total cost	$17,049.04

Annual Operating Cost Comparison

Item	**Cost**
Old system annual operating cost	$35,937.63
New system annual operating cost	$17,049.04
Annual operating cost change per year	$18,888.59

CAPITAL INVESTMENT REQUIREMENTS

Item	**Cost**	
AFBR System Capital Cost (pilot-scale system without gas handling equipment)	$140,000.00	
Approximate Cost of Shipping System to Site	$4,039.00	(see note 12)
Autodialer/Alarm	$1,500.00	
Influent Pump	$600.00	
Cost of Gas Handling Equipment (for flaring of gas)	Not Required	
Influent Storage Tank	$5,000.00	(see note 13)
Effluent Storage Tank	$500.00	(see note 13)
pH/Temperature Meter	$250.00	(see note 14)
Support Structure Capital Cost (including approximate shipping and construction costs)	$19,620.00	(see note 15)
Total Capital Cost of System	$171,509.00	

COST ANALYSIS SUMMARY

Item	**Cost**
New System Capital Cost	$171,509.00
Expected Service Life	20 years
Return on Investment per10-year period	$17,376.90 (10 x $18,888.59 – $171,509.00)
Break Even Point	9.1 years ($171,509.00 / $18,888.59)

FULL-SCALE SYSTEM ANALYSIS ***(takes into account only costs of deicing wastes)***

PREVIOUS METHOD: Offsite Disposal

Consumables **— N/A**

Labor **— N/A**

Electricity **— N/A**

Outside Laboratory Costs

Weekly analysis cost	$135.00	(see note 16)
Weeks of operation during which disposal is necessary (winter)	13	
Total annual analysis cost	$1,755.00	

Waste Disposal

Volume of AFFF Wastewater disposed of per year	0 gallons	
Cost for disposal per gallon	$3.00	
Volume of Deicing Fluid Wastewater disposed of per year	100,000 gallons	(see note 17)
Cost for disposal per gallon	$1.83	
Total cost per year	$183,000.00	

Total Annual Operating Costs

Item	**Cost**
Waste disposal	$183,000.00
Outside laboratory costs	$1,755.00
Total cost	$184,755.00

NELP METHOD: AFBR Pretreatment with Subsequent Discharge to NOTW (see note 18)

Consumables **– Treatment System Chemicals (see note 8)**

Cost per 55 gallon barrel of caustic	$181.00
Projected number of barrels used per year	87
Total cost of caustic per year	$15,747.00
Approximate cost of nutrients per gallon of wastewater treated	$.004785
Number of gallon of wastewater treated per year	100,000
Total cost of nutrients per year	$478.50
Total Annual Cost of Chemicals	$16,225.50

Labor (based on 300 consecutive operating days per year with weekly checks during non-operational period and using an available technician on a part-time basis)

Average hourly pay rate of Wastewater Plant Technician	$18.14	
Average man-hours per year to operate and maintain AFBR system	1,170	(see note 19)

Total Labor Cost Per Year	$21,223.80	

Electricity

Electricity rate per kilowatt-hour (kWh)	$0.0464	(see note 20)
Approximate total power draw for influent pump and system electronics (kW)	1.5	(see note 21)
Power draw for fluidization pump (kW)	2.238	(see note 21)
Power draw for compressor (kW)	3.73	(see note 21)
Projected compressor duty cycle	55%	(see note 21)
Average power draw for heater (kW)	2	(see note 21)
Annual hours of system operation	7,200	
Projected kWh required to operate AFBR system for one year	56,084.4	
Total Electricity Cost Per Year	$2,602.32	

Outside Laboratory Costs (see note 11)

Weekly analysis cost	$135.00
Weeks of operation/discharge	43
Total annual analysis cost	$5,805.00

Total Annual Operating Costs

Item	**Cost**
Consumables	$16,225.50
Labor	$21,223.80
Electricity	$2,602.32
Outside laboratory costs	$5,805.00
Total cost	$45,856.62

Annual Operating Cost Comparison

Item	**Cost**
Old system annual operating cost	$184,755.00
New system annual operating cost	$45,856.62
Annual operating cost change per year	$138,898.38

CAPITAL INVESTMENT REQUIREMENTS

Item	**Cost**	
AFBR System Capital Cost (100,000 gallon per year system without gas handling equipment)	$290,000.00	
Approximate Cost of Shipping System to Site	$1,700.00	(see note 22)
Programmable Logic Controller with Autodialer/Alarm	$5,000.00	
Approximate Cost of Flare Stack/Gas Handling Equipment (for flaring or capture of gas)	$20,000.00	
Effluent Discharge Pump	$600.00	
Influent Storage Tank	$79,000.00	(see note 13)
Effluent Storage Tank	$1,500.00	(see note 13)
pH/Temperature Meter	$250.00	(see note 14)

Support Structure Capital Cost (including approximate shipping and construction costs)	$19,620.00	(see note 15)
Total Capital Cost of System	$417,670.00	

COST ANALYSIS SUMMARY

Item	Cost
New System Capital Cost	$417,670.00
Expected Service Life	20 years
Return on Investment per10-year period	$971,313.80 (10 x $138,898.38 – $417,670.00)
Break Even Point	3.0 years ($417,670.00 / $138,898.38)

NOTES

1. Additional costs related to water usage and treated effluent disposal were not available for these analyses and should be considered when considering the implementation of the studied treatment system.
2. Calculations assumed existing base permits would cover treatment system permitting requirements without additional cost.
3. Although field chemical oxygen demand (COD) tests were performed daily during the pilot study, they would not generally be performed during the normal operation of the treatment plant. Consequently, the corresponding costs were not considered in the above analyses.
4. Calculations do not take into account potential cost savings related to energy value of biogas generated by treatment system operations. Burning the biogas generated by the full-scale system to power an existing boiler would reduce energy costs by approximately $12,072 (based on a biogas methane content of 64% and a natural gas cost of $0.93 per therm). Using the biogas as fuel for a fuel cell system (when they become commercially available) would eliminate combustion byproducts and would provide approximately $11,700 in electricity per year (based on a 29% efficiency rating for the fuel cell and an electricity cost of $0.0464 per kWh). A system designed to use the biogas for energy generation would require the additional purchase of a biogas blower ($1,600) and an on-line gas analysis (CO_2/CH_4) system ($10,000.00).
5. No outside laboratory costs were considered for the pilot-scale analysis existing method because no analyses were required at the time of the test's commencement.
6. Pilot-scale waste volumes are averages derived using NASWI disposal records for the years 1995 through 2000. Pilot-scale analysis used NASWI's average deicing fluid and AFFF waste generation volumes instead of the pilot system's projected treatment throughput capability when calculating annual operating costs and savings.
7. Cost calculations for the pilot-scale NELP method were based on a 270-day (39-week) operating period.
8. Caustic and nutrient costs for both analyses were conservatively based on the rate of usage experienced during the operation of the pilot-scale unit at NASWI. Actual long term caustic usage should be less because a full-scale system will be operated at steady state for the majority of the time whereas loading to the pilot-scale system was varied frequently in an attempt to determine maximum throughput and loading for two different wastes.
9. Pilot-scale analysis labor hours were based on observed hours required for operation of NASWI system together with provision for recommended annual maintenance activities. The requirements for the pilot-scale system were one hour of daily operation and maintenance (O&M) activities, two

hours of weekly O&M, 12 hours for monthly O&M, and 80 hours for annual maintenance. Note that only weekly O&M activities were assumed to continue during the system's non-operational period.

10. Electricity usage and costs for the pilot-scale analysis were based on the actual system usage and the local electric rate for the test period (respectively) as provided by NASWI personnel.
11. NPDES or sewer authority permits specify the frequency and types of required effluent testing. Once per week testing of typically regulated wastewater treatment effluent components [biochemical oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), and ammonia-nitrogen] were assumed for the calculation of outside laboratory costs. Per test costs were derived using an average of quoted prices obtained from various commercial laboratories.
12. Shipping costs for the pilot-scale system were based on a rate of $1.70 per mile with a starting location of Lansing Michigan (EFX manufacturing facility) and a destination of NASWI.
13. Tankage costs for both analyses were based on an average cost of $1.00 per gallon of tank capacity. For the pilot-scale analysis, it was assumed that wastewater (primarily AFFF wastes) generation would be fairly consistent throughout the course of the year, but treatment would occur only during a nine-month period. For the full-scale system, it was assumed that the majority of the wastewater (deicing wastes) that is going to be treated over the system's ten-month operating period would be generated during a three-month winter season.
14. A pH/temperature meter (used to monitor reactor health performance) was included in the capital costs of both the pilot-scale and full-scale treatment systems.
15. Support structure costs for both units were based on the purchase and installation price of a Sprung Structures building approximately 30 foot in diameter and approximately 14 foot high. Additional costs would be incurred if an additional support structure is required or foundation upgrade is needed.
16. Outside laboratory costs for the full-scale existing method were based on a 13-week disposal season and assumed that analysis of the untreated waste was required on a weekly basis prior to disposal. Outside laboratory costs for the full-scale NELP method were based on a 300-day (43-week) operating period.
17. Full-scale waste volume was derived using NAS Brunswick glycol usage records and the expected percent glycol content of deicing wastewater. NAS Brunswick data was used when it was determined that NASWI would not generate sufficient wastewater volume to make a full-scale system practical.
18. Cost calculations for the full-scale NELP method were based on a 300-day (43-week) operating period.
19. Because of the increased size and complexity of the full-scale system, daily, weekly, and monthly labor hours were doubled and annual maintenance labor hours were increased by 50% for purposes of the full-scale system cost analysis. Note that only weekly O&M activities were assumed to continue during the system's non-operational period.
20. Electricity unit cost for the full-scale analysis was based on the year 2000 U.S. national average price per kWh for industrial customers as provided by the Energy Information Administration (EIA).
21. Electricity usage for the full-scale system was based on projected usage data supplied by the treatment system vendor.
22. Shipping costs for the full-scale system were based on a rate of $1.70 per mile with a starting location of Lansing Michigan (EFX manufacturing facility) and a destination of NAS Brunswick.